Chapter 11
Clean Formation Interpretation

Lecture notes for PET 370
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Clean Formation Interpretation

Applications

- porosity in formations with unknown and/or multiple minerals
- mineralogy determination
- secondary porosity detection
- evaluation of mineral deposits such as sulfur, coal, potash, uranium
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- Clean formation; i.e., no shale fraction
- Formation composed of two discernable minerals, $V_1$ and $V_2$
- Pore space is liquid-filled.
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Idealized CNL-FDC response in common lithologies (Pirson, 1963)
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Example CNL-FDC response from Northern Rocky Mountain Well (Pirson, 1963)
• Combine two porosity logs (density, neutron, or sonic) onto one chart.

• Use a reference scale, typically limestone, known as apparent limestone porosity units.
  • neutron from equivalence charts
  • sonic from transit time charts
  • density from mass balance equation

• Three equations for three unknowns

\[
\rho_b = f(\phi, V_1, V_2) \\
\phi_n = f(\phi, V_1, V_2) \\
1 = \phi + (1-\phi)*(V_1 + V_2)
\]

where \(V_1\) and \(V_2\) are volumetric mineral fractions as percent of grain volume.

• Isoporosity and constant mineral scales
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**Selection of crossplot:**

1. based on tool types
2. Age of CNL tool (pre 1986)
3. fluid density, $\rho_f = 1.0$ or 1.1 gm/cc
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Example
Determine the porosity and lithology of points A through E on the attached FDC - CNL log. The mud density is 1.1 gm/cc and the CNL was run before 1986.
Determination of $\rho_{maa}$ from FDC and CNL logs (Fresh mud)
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Analytical solution

\[ U = \phi U_f + (1 - \phi) \sum_{i=1}^{3} V_i \cdot U_{ma_i} \]

\[ \phi_N = \phi(H_n)_{f} + (1 - \phi) \sum_{i=1}^{3} V_i \cdot H_{Nma_i} \]

\[ \rho_b = \phi \rho_f + (1 - \phi) \sum_{i=1}^{3} V_i \cdot \rho_{ma_i} \]

\[ \phi + (1 - \phi) \sum_{i=1}^{3} V_i = 1 \]
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Graphical

1. M/N plot - Combine sonic, density, and neutron readings to minimize porosity effect and maximize matrix effect.

M/N Plot Limitations
- Separation between sandstone, limestone, and dolomite points is narrow, resulting in ambiguous answers.
- Tedious calculations
- M and N lack any physical meaning
- Multiple matrix points for varying porosity ranges.
- Readings affected by: shale, gas, secondary porosity, evaporates.

2. MID plots
  a. Density-neutron-sonic
  b. Density-neutron-Pe

Best
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- inputs are $\rho_b$, Pe from LDT and $\phi_N$
- Determine $\rho_{maa}$ and $\phi_{xp}$

\[
\phi_{xp} = \frac{\phi_n + \phi_d}{2}
\]

\[
\rho_{maa} = \frac{\rho_b - \phi_{xp}\rho_f}{1 - \phi_{xp}}
\]

- Determine $U$, volumetric photoelectric absorption index from:

\[
U = \frac{P_e (\rho_b + 0.1883)}{1.0704}
\]
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- By volume balance,

\[ U = \phi_{xp} U_f + (1 - \phi_{xp}) U_{maa} \]

Where

- \( U_f \) is the fluid volumetric index
- \( U_{maa} \) is the apparent matrix...index

or

\[ U_{maa} = \frac{U - U_f \phi_{xp}}{1 - \phi_{xp}} = \sum_{i=1}^{3} V_i \ast U_{maa} \]
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Exercise
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Chapter 14

References


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